Asian Journal of Science and Applied Technology
ISSN: 2249-0698 (P) Vol.5 No.1, 2016, pp.17-19

DOI: https://doi.org/10.51983/ajsat-2016.5.1.2542

Experimental Analysis of Rotor-Bearing System for Fault Detection

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(Received 6 January 2016; Revised 27 January 2016; Accepted 15 February 2016; Available online 22 February 2016)

***Abstract* - Rotating system is a main part in any industry. The design of such systems in modern engineering is towards lower weight operating at super critical speed for longer periods of time. In actual working condition, faults are unavoidable due to the error in manufacturing; faults may develop in the system due to the operating conditions such as heat generation, unbalance, wear, misalignment, looseness etc. In this study, dynamic behavior of rotor-bearing system is studied. This model mainly represents the driving unit at industrial machine applications. Disc at the model can be considered as gear or pulley, etc .at the transmission line. Experimental vibration analyses in vertical direction of the system are implemented. Vibration monitoring with Run up measurement analysis and Spectrum graphs are used to diagnose the excessive vibration source. It is seen that vibration at the rotor-bearing system not only one faults but also combination of several faults such as unbalance, wear, misalignment, looseness, etc. A non-destructive evaluation method for left & right bearing is used to diagnose the undue vibration source before it become critical.**
***Keywords:* Rotor unbalance, vibration analysis, FFT analyzer, Fault detection.**

I. INTRODUCTION

In mechanical area various rotary systems available such as motor, turbine, engines are operating on shafts which are rotating at different speed. The dynamic performance of bearing affects the performance of rotary machines. Experimental studies will be performed on rotor bearing system to determine vibration level for different types of fault**.** Unequal distribution of mass in a rotating member is the cause of unbalance which leads to centrifugal forces in radial direction. When system is unbalanced unnecessary vibration occurs, further it may generate unwanted noise, reduce reliability of a rotary system. Vibration generated by these defects plays an important role in condition monitoring of rotary a system. The defects are developed in bearings but unfortunately we cannot observe these defects by eyes in initial stage of failure. But when these faults are increased to large amounts, it will lead to damage. So it is very important step to detect faults in an bearing at an earlier stage.

1.1 Direct coupled rotor bearing system

Rotor-bearing system consists of a simply supported flexible massless shaft with a rigid disc mounted at the mid-span. The shaft of the rotor is supported rigidly at its ends using ball bearing. The outer race of the ball bearing fixed to a rigid support and the inner race fixed rigidly to the shaft. The disc center of rotation, C, and its center of gravity, G, is offset by a distance, μ, which is called the eccentricity.[1]

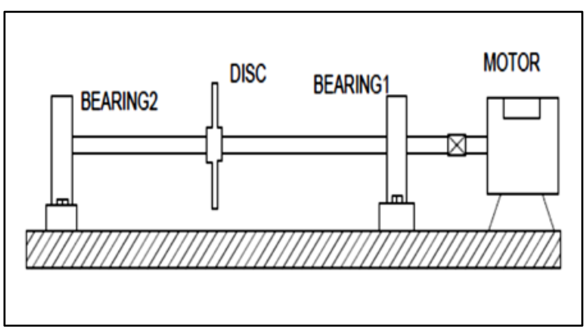

Fig.1 Description of the system

II. LITERATURE REVIEW

Sudhakar and Sekhar [2] studied the two different approaches viz. equivalent load minimization and vibration minimization. These methods were applied for the identification of unbalance fault in a rotor system by measuring the transverse vibrations at only one direction. The different unbalance masses at different phase angles were added to the disc and resultant vibration displacement were measured.

Tiwari et. al. [3] studied the nonlinear behaviors of a balanced rotor due to the effect of internal clearance of the ball bearing. Also unbalance rotor was analyzed. The result of increased clearance was to increase the strength of super harmonics, and the strength of backward whirl components. Higher clearance generated more sub harmonic components in response compared to the case when the bearing was with lesser clearance.

McFadden and Smith [4] studied the vibration created by multiple point defects in a rolling element bearing was showed. A model for the high frequency vibration formed by a single point defect on bearing inner race under radial load is extended to describe the vibration produced by multiple point defects. The phase angles were derived for defects at any position on the inner race and superposition was used to give the vibration spectrum.

Kankar et al. [6] have proposed an analytical model of a rotor bearing system to obtain the nonlinear vibration response due to localized defects. The mathematical formulation predicted discrete spectrum with peaks at the characteristic defect frequency and their harmonics. From various trials it has observed that nonlinear dynamic responses are associated with high rotor speed and due to localized defects on inner and outer races. Also the effects of localized defects with two levels of rotor speed have been investigated and the combined effect of the various localized parameters has been checked. The system showed periodic nature when ball defect was at maximum level with rotor speed of 1000 rpm.

III. EXPERIMENTAL STUDY

Understanding the state of the machine can monitored and detailed analyses concerning the health of the machine and any faults which may be arise or have already arisen may be made. Whenever a mechanical system is in operation vibration starts automatically due to system instability and more often vibrations due to some externally applied load such as, cracked or bent shafts, mass unbalance etc. This chapter explains the experimental setup for studying dynamic behavior in a simple rotor-bearing system such as the rotor is placed eccentrically on the shaft and running at constant speed.

3.1 Experimental set up

The experimental test rig of direct coupled rotor-bearing system as shown in Fig.3.1.It mainly consist of mild steel shaft (25mm diameter and 1000mm length)and centrally located steel disc(1.45 kg weight).These type of system generally used in the industrial machine application for purpose of power transmission or driving unit. The shaft is supported in identical rolling element bearing at its two ends with type of UCP 205ball bearing. Experimental test rig consist of coupling, shaft, disc, two bearing with pillow block, frame body, AC speed control unit and FFT analyzer with display.

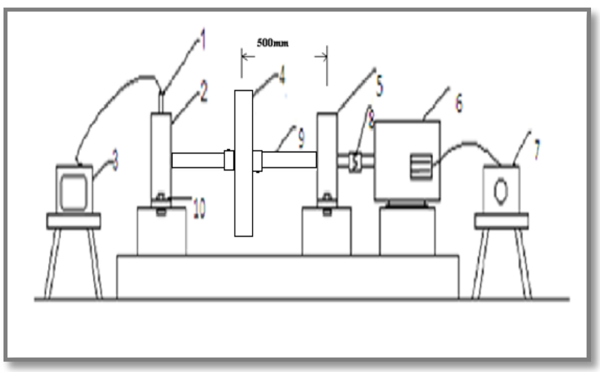

Fig.1. Schematic representation of the test rig and components

IV. RESULTS AND DISCUSSION

Disc is mounted at mid length of shaft for constant speed500rpm

For this condition of disc is placed at mid length of shaft, system to be run at constant speed 500 rpm during run up test and data of run up is recorded.

4.1Displacement (μm) at constant speed 500rpm for Bearing 1(Right side)

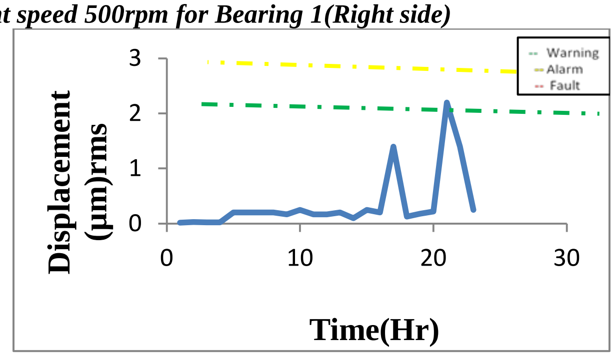

Fig..4.1 Graph of displacement with respect to time (Right side)

TABLE4.1FAULT PARAMETERS FOR THE RIGHT BEARING

Indication	Displacement in (μm)
Warning	1.719
Alarm	2.286
Fault	3.048

Vibration trend of Right bearing in model system is given in fig.4.1. From that three level of machine condition obtained such as, Warning, Alarm, and Fault. Maximum value of amplitude in fig.4.1 is 2.2 μm. In table 4.1 shows the values of fault parameter.

4.2Displacement (μm) at constant speed500rpm for Bearing 2(Left side)

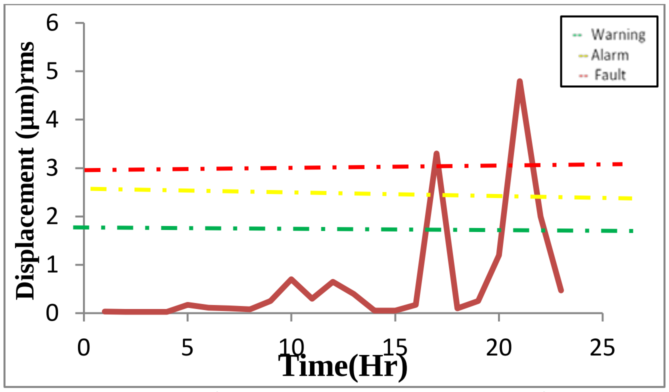

Fig..4.2 Graph of displacement with respect to time (left side)

TABLE 4.2 FAULT PARAMETERS FOR THE LEFT BEARING

Indication	Displacement in (μm)
Warning	1.719
Alarm	2.286
Fault	3.048

Vibration trend of Left bearing in model system is given in fig.4.2.The maximum value of amplitude in fig.4.2 is 4.8 μm. In table 4.2 shows the values of fault parameter.

IV. CONCLUSION

In this experimental study, the direct coupled rotor-bearing system is implemented to investigate the undue vibration characteristics. Vibration monitoring is a non-destructive evaluation method for left and right bearing is employed to diagnose the possible faults in the model. Vibration level trend analysis for each bearing is accomplished in regular period to calculate the fault parameter. The evaluated vibration result for each bearing shows that there are mechanical looseness and misalignment in the system. These faults in the system take place between left and right bearing axis and coupling. Also these random vibration sources lead to additional vibration at the mechanical system.

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